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# Physicochemical , Microbial, and Sensory Properties of Yoghurt Supplement with Inulin Rich Carbohydrates Extract from Jerusalem Artichoke Tubers during Storage

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## ABSTRACT

The purpose of this study was to evaluate the effect of inulin rich carbohydrates extract from Jerusalem artichoke tubers on physicochemical, textural, and microbiological properties of the yoghurt during storage. Five formulations of yogurt were prepared with the addition of 0, 1, 3, 5, 7 or 10% of inulin rich carbohydrates extract from Jerusalem artichoke tubers. During storage at 4ºC, the pH of yoghurt treatments supplement with 3, 5 and 7% inulin extract from Jerusalem artichoke tubers and the control (0% adding) was rapidly decreased during 14 days storage (from 4.45 to 4.36). The viscosity was slightly increased and reached the highest value of 3080 Cps. in the yoghurt supplement with 7 and 10% inulin extract from Jerusalem artichoke tubers. Both *L. delbrueckii* subsp. *bulgaricus* and *S. thermophilus* were not able to ferment inulin extract from Jerusalem artichoke tubers under the conditions study due to no significant survival counts of the yoghurt strains neither acidification between the yoghurt treatments supplement with inulin extract from Jerusalem artichoke tubers and the control was observed. Inulin rich carbohydrates extract from Jerusalem artichoke tubers causes alterations in sensory perception. More concentrations of inulin extract from Jerusalem artichoke tubers adding resulted to more slightly decrease in overall acceptance compare to the control yoghurt. However, yoghurt adding with 3% inulin extract from Jerusalem artichoke tubers was improved some physical properties (flavor and texture) and reach the highest score (8.10) in overall acceptance compare to control yoghurt (8.00).

**Keywords:** Jerusalem artichoke tubers; sensory properties; yoghurt

## INTRODUCTION

Milk and dairy products have an important role in human diet due to their many nutritional benefits from proteins, lactose, minerals and water-soluble vitamins (Ozturkoglu-Budak, Akal, & Yetisemiyen, 2016). Yoghurt is among the most common dairy products available in various textures (i.e., liquid, set, smooth), fat contents (luxury, low-fat, virtually fat-free) and flavours (natural, fruit, cereal) (Shah, 2003, McKinley, 2005) that consumed around the world. It is traditionally made from the spontaneous or induced lactic acid fermentation of milk (Widyastuti, Rohmatussolihat, & Febrisiantosa, 2014) and its sensory attributes have a large effect on consumer acceptability (Saint-Eve et al., 2006). As the popularity of yoghurt products continues to grow, manufacturers are continuously investigating value-added ingredients such as prebiotics and probiotics to entice health-conscious consumers.

Inulin is found in many plants as a storage carbohydrate and has been part of the human daily diet for several centuries. It presents in over 3000 vegetables such as onion, garlic, chicory, and sunchoke (or Jerusalem artichoke) (Judprasong, Tanjor, Puwastien, & Sungpuag, 2011; Van Loo, Coussement, DeLeenheer, Hoebregs, & Smits, 1995). Two major functions of Inulin are soluble dietary fibre and prebiotic. Owing to its nutritional and physiological properties, inulin has increasingly been used as an ingredient in processed functional foods that can improve taste, texture, and moisture in many foods.

Since, Jerusalem artichoke is growing importance in food products in Thailand, the main objectives of this study were to produce a new yogurt fortified with inulin rich carbohydrates extract from Jerusalem artichoke tubers and to evaluate its effects on physicochemical, textural, and microbiological properties of the obtained yoghurt during 21 days of storage.

## MATERIALS AND METHODS

### Preparation of inulin rich carbohydrates extract from Jerusalem artichoke tubers

Jerusalem artichoke tubers grown and harvested in Mahasarakham, was purchased from Department of Agricultural Technology, Mahasarakham University. Dried-slices Jerusalem artichoke obtained from fresh tubers were ground to obtain a homogeneous powder. Inulin rich carbohydrates were extracted in boiled-distilled water for 30 min, with a solid:solvent ratio of 1:5 (w/v).The solution was separated from the slurry by filtrations through muslin cloth and paper filter. Then the extract was kept at 4°C until further use.

**Production of inulin addition yoghurts**

Five experimental yoghurts were prepared. The list of all ingredients used was shown in Table 1. Inulin rich carbohydrates extract from Jerusalem artichoke tubers was added to the cow milk at the level of 0, 3, 5, 7 and 10 %, then these were heated for pasteurization at 85 °C for 20 min with constant agitation to dissolve the powder in milk. After immediately cooling to 42°C, the mixtures were inoculated with 5% starter culture, 1-day old yoghurt (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*) in equal proportions (Robinson, R. K., & Tamime, A. Y., 1994). After slow agitation for 10–15 min to distribute the cultures evenly, the inoculated milk samples were aseptically transferred into 100 ml plastic containers and maintained 4.0 h at 43 °C ± 0.1 until the pH reached 4.4. Resulting yoghurt was cooled to 4°C. All trials were replicated three times. Physicochemical properties of yoghurt samples were analyzed every 7 days during storage at 4°C.

**Table 1**. Formulation for manufacturing yoghurt with different levels of inulin rich carbohydrates extract from Jerusalem artichoke tubers

| Yoghurt formulas | ingredients | | | supplement |
|---|---|---|---|---|
| | Cow milk (ml) | Skim milk powder (%) | Sugar (%) | inulin rich carbohydrates extract from Jerusalem artichoke tubers (%) |
| 1 (control) | 2,000 | 4 | 7 | 0 |
| 2 | 2,000 | 4 | 7 | 3 |
| 3 | 2,000 | 4 | 7 | 5 |
| 4 | 2,000 | 4 | 7 | 7 |
| 5 | 2,000 | 4 | 7 | 10 |

## Analytical determinations of yoghurt

**Determination of pH**

The pH of yoghurt was measured using a bench-top pH-meter which was previously calibrated with pH 7.0 and 4.0 standard buffers. All analyses were carried out in duplicate.

**Determination of titratable acidity (TA)**

Titratable acidity (as % lactic acid) of yoghurt was determined in duplicate according to the AOAC titration method using 0.1 M NaOH (AOAC, 2005).

**Determination of viscosity**

The viscosity of yoghurt was determined in duplicate using a rotational viscometer (Brookfield, DV-E, USA) in a 100 mL sample at 25 °C.

**Determination of bacterial counts**

A yoghurt sample (1 g) was suspended in 9 ml of sterile 0.1% (w/v) peptone water and subsequently serially diluted to $10^{-7}$. Counts of *S. thermophilus* were enumerated using the pour plate technique after aerobic incubation at 37°C for 72 h on M17 agar and enumeration of *L. delbrueckii* ssp. *bulgaricus* was performed using MRS agar incubated at 37°C for 72 h under anaerobic conditions. Bacterial viability was assayed as described Grimoud et al. (2010). The percentage of bacterial survival during storage was calculated as follows:

$$\% \text{ survival} = \frac{\text{cfu/g after}}{\text{cfu/g before}} \times 100$$

Where cfu/g represents cell viability at the beginning (h=0) and after storage (d. 7-21) as described above.

**Sensory evaluation of yoghurts**

The sensory evaluation of yoghurts was undertaken by means of the acceptability test and the ninth-grade hedonic scale (Sant'Anna et al., 2014). The five samples were evaluated a day after preparation by 30 untrained panelists (20–25 years old). During the assessment, each panelist qualified a sample on a nine-point scale where one represented the lowest intensity of liking and nine the highest intensity of liking for the sensory properties of color, aroma, flavor, texture and overall acceptability.

### Statistical analysis

All measurements described above were obtained in triplicate and the results are shown as average ± standard deviation. One-way analysis of variance and Duncan's test analysis of means were employed to determine significant differences among treatments. Values were considered significant when $p < 0.05$. Statistical analysis was performed using the SPSS 18.0.

## RESULTS AND DISCUSSION

### Changes in pH and titratable acidity

The changes in pH of different yogurts supplemented with inulin rich carbohydrates extract from Jerusalem artichoke tubers were presented in Figure 1. The pH of control (no inulin extract from Jerusalem artichoke tubers adding) and yoghurt treatments supplement with 3, 5 and 7% inulin extract from Jerusalem artichoke tubers was rapidly decreased during 14 days of storage (from 4.45 to 4.36) and slightly increased until the end of 21 days storage. Except for the yoghurt treatments supplement with 10 % inulin extract from Jerusalem artichoke tubers was slightly decrease during 7 days storage followed by slightly increase until the end of 21 days storage. Meanwhile, the acidity of yoghurt treatments showed the values in contrast with the pH levels (Figure 2). This notice that the greatest changes in pH and acidity took place within the first week of storage might be resulted from residual lactose fermentation which was indicative of acid-producing microorganisms (Moschopoulou et al., 2018). Therefore, the high population of lactic acid bacteria present in yoghurts can lead to a high acid production, which may explain the increase in titratable acidity during storage.

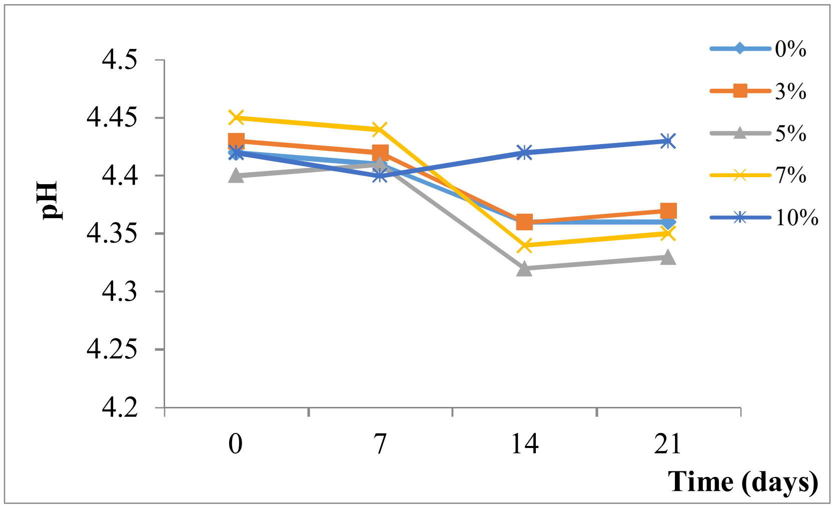



**Figure 1** Change of pH of 5 yoghurts added of inulin rich carbohydrates extract from Jerusalem artichoke tubers during storage at 4oC for 21 days

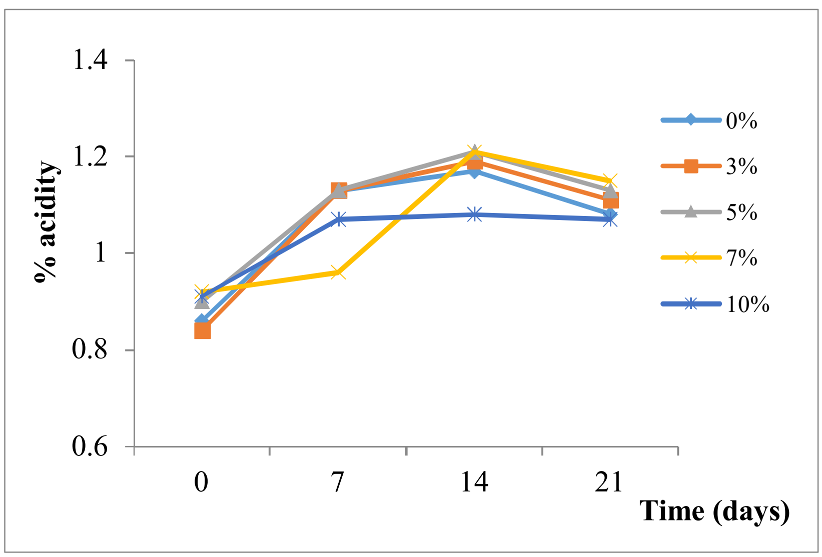
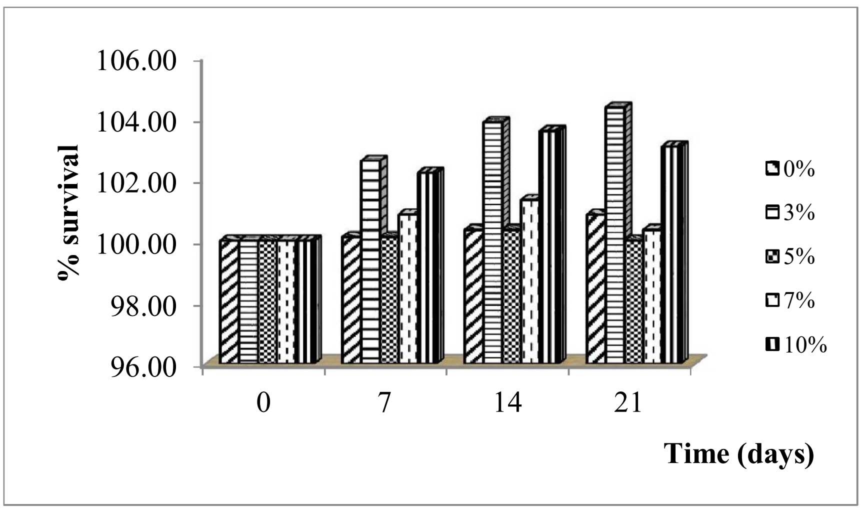



**Figure 2** Change of titratable acidity (%TA) of 5 yoghurts added of inulin rich carbohydrates extract from Jerusalem artichoke tubers during storage at 4°C for 21 days

**Changes in the survival counts of yoghurt bacteria**

Fig. 3 showed almost constant growth (100% survival counts) of the strain *L. delbrueckii* subsp. *bulgaricus* in control yoghurt and yoghurt supplemented with 5% inulin rich carbohydrates extract from Jerusalem artichoke tubers, meanwhile the survival counts of *L. delbrueckii* subsp. *bulgaricus* in yoghurt supplemented with 3%, 7% and 10% inulin rich carbohydrates extract from Jerusalem artichoke tubers showed slightly increase during 21 days of storage. The highest survival counts (104.34%) of *L. delbrueckii* subsp. *bulgaricus* was found in yoghurt supplemented with 3% inulin rich carbohydrates extract from Jerusalem artichoke tubers after storage for 21 days. However, the survival of *L. delbrueckii* subsp. *bulgaricus* in treatment yoghurt did not present significant differences ($p > 0.05$) with the control that had no inulin extract adding.




**Figutr 3.** Survival counts of *L. delbrueckii* subsp. *bulgaricus* in yoghurts added of inulin rich carbohydrates extract from Jerusalem artichoke tubers during storage at 4ºC for 21 days

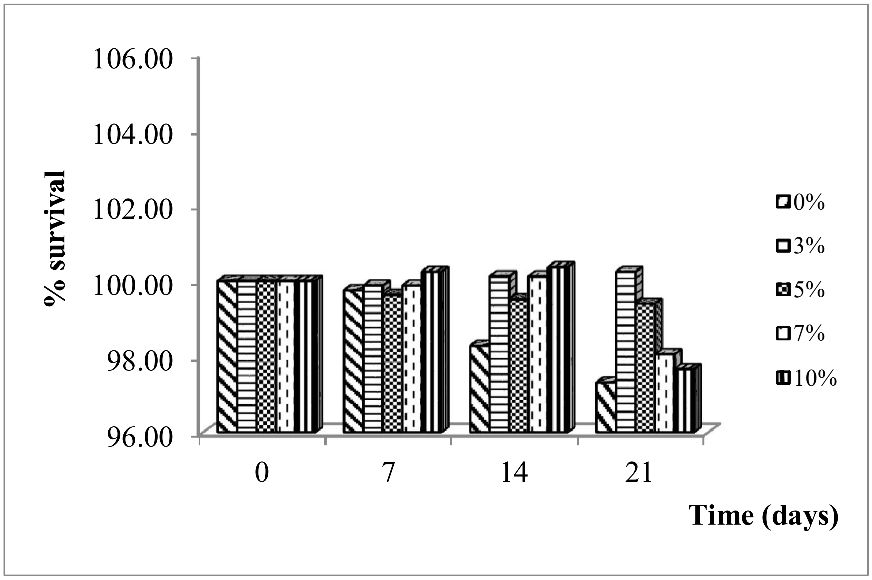



**Figure 4** Survival counts of *S. thermophilus* in yoghurts added of inulin rich carbohydrates extract from Jerusalem artichoke tubers during storage at 4ºC for 21 days

The survival counts of *S. thermophilus* during 21 days of storage in control yoghurt was slightly decrease (100 to 97.31%) but almost 100% survival counts of *S. thermophilus* was detected in yoghurt supplemented with 3% inulin rich carbohydrates extract from Jerusalem artichoke tubers. Meanwhile the 100% survival counts of *S. thermophilus* in yoghurt supplemented with 5%, 7% and 10% inulin rich carbohydrates extract from Jerusalem artichoke tubers was found during 14 days storage and followed by slightly increased in 21 days of storage (Fig. 4). Similar to *L. delbrueckii* subsp. *bulgaricus*, the survival of *S. thermophilus* in yoghurt supplemented with inulin rich carbohydrates extract from Jerusalem artichoke tubers during 21 days storage did not present significant differences ($p > 0.05$) with that control.

This result indicated that both *L. delbrueckii* subsp. *bulgaricus* and *S. thermophilus* were not able to ferment inulin extract from Jerusalem artichoke tubers under the conditions study that might be these strains may not have the enzymatic machinery necessary for the inulin metabolism. Previous report, Carolina et al. (2019) studied the effect of inulin extracted from Jerusalem artichok (*Helianthus tuberosus* L.) tubers on the growth and probiotic properties of different Lactobacillus strains such as *Lactobacillus casei* BGP93, *Lactobacillus paracasei* BGP1, *Lactobacillus acidophilus* TCC314 and *Lactobacillus plantarum* CIDCA8327 which found that only strains of *L. paracasei* BGP1 and *L. plantarum* CIDCA8327 were able to ferment inulin form Jerusalem artichoke tubers, since no significant growth of the strains neither acidification of the media was observed.

**Changes in viscosity**

The effect of inulin rich carbohydrates extract from Jerusalem artichoke tubers addition on the viscosity of yogurt during 21 days of storage was shown in Figure 5. The viscosities of all treatment yogurts were slightly increased from the initial day to 14 days of storage period then were slightly decreased until the end of storage period. In the early stage of storage time, viscosities in all yogurt samples were slightly increased due to the rearrangement of the protein molecules (Sahan et al., 2008). Meanwhile, in the final day of storage, the viscosities of all samples, including the control, had decreased. That might have been caused by the whey separation with increasing storage time. However, the results did not present significant differences ($p > 0.05$) in the viscosity between all treatment yoghurts supplement with inulin rich carbohydrates extract from Jerusalem artichoke tubers and the control yoghurt.

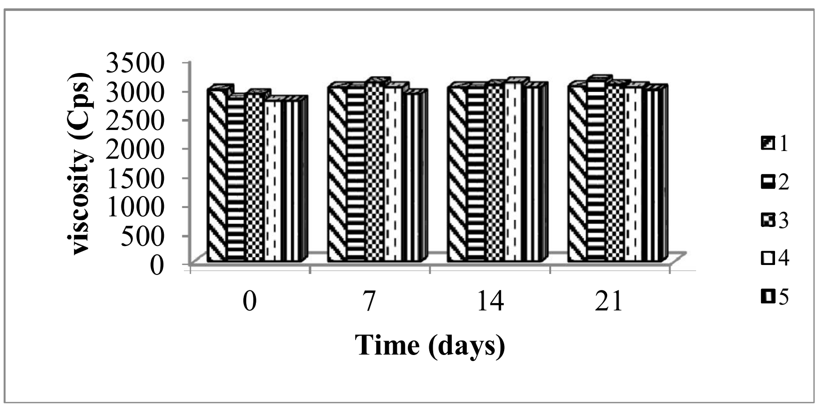



**Figure 5.** Change of viscosity of 5 yoghurts added of inulin rich carbohydrates extract from Jerusalem artichoke tubers: (1) 0%, (2) 3%, (3) 5%, (4) 7% and (5)10% during storage at 4ºC for 21 days

**Evaluation of sensory perception**

Results of sensory evaluations of treatment yoghurts for color, flavor, taste, mouth texture, and overall acceptability were shown in Table 2. The result of hedonic scale showed the lowest scores (7.50) for yogurt adding with 10% inulin rich carbohydrates extract from Jerusalem artichoke tubers.

Treatments yoghurt adding with higher inulin extract concentrations possessed lower sensory acceptability for all organoleptic properties compared to yoghurt adding with lower inulin extract concentrations and the control ($p < 0.05$), due to the undesirable aroma and flavor from Jerusalem artichoke tubers. A satisfactory yoghurt mouth-feel can be attained through the incorporation of high levels of total solid, fat, protein and flavor attributes (Özer, 2006). The result of hedonic scale for overall acceptability of yogurts containing 3% inulin rich carbohydrates extract from Jerusalem artichoke tubers showed the highest scores for treatment yogurts (8.10), however it did not present significant differences ($p > 0.05$) with the treatment of control (8.00).

**Table. 2** Mean scores of tasting panellists for sensory properties of control and yogurts adding with inulin rich carbohydrates extract from Jerusalem artichoke tubers (1) 0%, (2) 3%, (3) 5%, (4) 7% and (5) 10%) evaluated at a day after preparation. Different lowercase letters ($^{a, b,c,d}$) in a column denote a significant difference ($p < 0.05$).

| Samples (formulas) | Sensory attributes | | | | |
|---|---|---|---|---|---|
| | color | aroma | flavor | texture | overall acceptability |
| 1 (control) | 8.10±0.91$^{c}$ | 7.55±1.19$^{c}$ | 7.65±1.04$^{c}$ | 7.65±1.31$^{c}$ | 8.00±1.17$^{b}$ |
| 2 | 7.60±1.14$^{b}$ | 7.05 ±1.36$^{a}$ | 8.05±0.69$^{d}$ | 7.70±1.30$^{c}$ | 8.10±0.89$^{b}$ |
| 3 | 7.45±0.95$^{a}$ | 7.00±1.12$^{a}$ | 7.45±1.42$^{b}$ | 7.25±1.48$^{b}$ | 7.65±0.88$^{a}$ |
| 4 | 8.00±1.08$^{c}$ | 7.30±1.56$^{b}$ | 7.30±1.36$^{a}$ | 7.05±1.73$^{a}$ | 7.65±1.39$^{a}$ |
| 5 | 7.75±1.33$^{b}$ | 6.95±1.43$^{a}$ | 7.20±1.73$^{a}$ | 6.95±1.61$^{a}$ | 7.50±1.47$^{a}$ |

## CONCLUSION

This study was undertaken to produce a new yogurt fortified with inulin rich carbohydrates extract from Jerusalem artichoke tubers and to evaluate the change in physicochemical, textural, and microbiological properties of the obtained yoghurt during storage at 4°C for 21 days. The resulting data on pH, viscosity, survival counts of yoghurt starter cultures and sensory evaluation from this study suggested that the supplementation of inulin rich carbohydrates extract from Jerusalem artichoke tubers did not show any adverse effect on the yogurt quality. Therefore, we conclude that inulin rich carbohydrates extract from Jerusalem artichoke tubers (3%v/v) could be applicable to the manufacture of functional yogurt.

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